Net Metering in British Columbia

White Paper

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1 Introduction

On January 30, 2003, in response to applications from several customers, the B.C. Utilities Commission (BCUC) requested BC Hydro to prepare a report on the merits of net metering in order to support consultations on a possible net metering tariff application by BC Hydro. Specifically, the Commission requested information on:

- Definitions of net metering;
- Experience of other jurisdictions with net metering;
- Possible costs and benefits of net metering from the perspective of both BC Hydro and ratepayers;
- Potential for net metering of small generators in B.C; and
- Barriers and policy considerations for successful implementation of net metering.

The following paper is intended to support deliberations by the BCUC on the possible strategic value and structure of a net metering policy in British Columbia. It makes no specific recommendations. More analysis may be required to support detailed program design and implementation if the BCUC finds sufficient justification and support for a net metering policy. There are also alternative or complementary policies to net metering that may need to be considered.

2 Definitions

On-site generation is often installed at remote sites as an alternative to extending the electricity grid. Provided they meet equipment and interconnection standards intended to protect public/worker safety and local power quality, grid-connected customers can also install on-site

generation to displace their loads and reduce their bills.[1] However, even where generation is sized to meet a customer's average or annual requirements, there may still be times when their supply exceeds their demand. This is particularly common with intermittent resources such as wind or hydro.

Net metering is a policy tool for promoting small-scale, grid-connected generation at homes and businesses, typically defined as systems of less than 50 kW in size.[2] It allows customers to sell or "bank" their excess generation, increasing the value they derive from their on-site generation. In the absence of a net metering policy, customers would need to install smaller systems and/or electricity storage devices to capture excess generation for use when consumption exceeds generation.

Under the simplest version of net metering, there is a single meter that runs backwards when the generator produces more electricity than the customer requires and runs forward when the generator produces less than the customer requires.[3] Customers are billed only for their "net consumption". The on-site generation is effectively valued at retail rates, which may or may not reflect the value of the generation.[4]

An alternative to simple net metering is *net billing*. Under net billing, customers pay retail rates for their net or gross consumption and receive a different avoided cost rate for their net or gross electricity production. There are many possible variations of net billing. Net

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[1] The grid still supplies supplemental and/or back-up power for these customers.

[2] Size of systems eligible for net metering varies (see Section 3).

[3] This is not possible with a detented meter.

[4] Retail rates are based on embedded (average) cost of generation and typically include other fixed costs such as transmission and distribution costs. The discrepancy between retail rates and market value of generation varies greatly across jurisdictions. For example, in many U.S. jurisdictions, retail rates greatly exceed avoided generation costs. In British Columbia, retail rates are equal to or lower than avoided generation costs due to the low embedded costs of British Columbia's existing large hydroelectric facilities. There are also many different interpretations of avoided costs – e.g., short-run variable costs of market power, long-run marginal costs of conventional supplies, or long-run marginal costs of other green energy supplies. Value can also include non-financial values (e.g., greenhouse gas emission reductions).

billing requires the installation of a bi-directional meter or two separate meters.

Many utilities use the term net metering when in fact they are practicing net billing, or vice versa. This makes it difficult to determine the actual extent of different approaches. Simple net metering is more common, although programs still vary in their treatment of net excess generation across billing periods.

3 Policy Objectives

Net metering may support several electricity policy objectives. Possible objectives could include:

- Provide greater customer choice / control over their electricity source.
- Support commercialization of small-scale technologies by creating a potential market for these technologies.
- Increase diversity of energy supplies.
- Promote economic development (e.g., new manufacturing and/or service opportunities in new technologies).
- Reduced environmental impacts (e.g., greenhouse gas emissions).[5]
- Reduced electricity system costs and/or improved system reliability.

The degree to which net metering supports any or all of these objectives will vary across jurisdictions and programs, depending upon factors such as program design, avoided costs and sources of supply, existing system conditions, retail rates, and likely customer

[5] This assumes that net metering is limited to technologies with environmental advantages.

response. The relative importance of different objectives will also vary across jurisdictions and stakeholders.

The benefits of net metering must also be weighed against potential costs or other impacts, as well as other options for meeting these policy objectives. Some potential costs or impacts include:

- Additional planning, administrative and metering costs associated with establishing and maintaining a net metering program.[6]
- Higher electricity costs and/or lost opportunities.
- Risks to public safety or local power quality.[7]

Distributional impacts may also be important. Under certain circumstances, net metering could lower costs for participating customers while increasing costs for non-participating. In some cases, distributional impacts may be justified on the basis of broader societal benefits.

4 Design Considerations

The actual design of net metering programs varies greatly across jurisdictions, reflecting different constraints, values and trade-offs. In many jurisdictions, net metering is mandated by government or regulatory policy. Some of these policies are very prescriptive. Others are more general, leaving the detailed design to individual utilities.

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[6] This may include both hard direct costs as well as softer costs associated with the diversion of personnel from other important initiatives.

[7] Safety issues are a major concern of most utilities. They arise from the possibility of islanding – i.e., lines remain energized when the rest of the grid is down, posing risks to lineworkers. These issues can be addressed through automatic and/or manual solutions, as well as signage and education. However, some of these solutions can also increase the costs of on-site generation.

Some key considerations in designing a net metering program include the following.

- Form of metering and billing arrangements, including treatment of net excess generation.
- Interconnection requirements.
- Eligible technologies and system sizes.
- Eligible customers.
- Limits on overall enrollment.
- Linkages with other policies.

4.1 Form of Metering and Billing

There are several options for structuring metering and billing arrangements. Two examples include:

- Simple net metering – single meter capable of rotating backwards, with all on-site generation valued at retail rates. Programs may vary in terms of how long excess net generation can be carried forward.
- Net billing with a single bi-directional meter or two uni-directional meters with net consumption billed at retail rates and net exports credited at a different avoided cost rate.[8]

[8] With two meters it is also possible to have separate rates for gross consumption and gross production, with gross consumption billed at retail rates and gross production credited at an avoided cost rate. This is sometimes justified as a means of preventing customers from bypassing historical or fixed costs, which would shift to other customers, and to provide a more realistic price signal regarding the value of generation to society. However, this approach is also criticized for further reducing the attractiveness of small-scale generation, which may have other societal benefits not reflected in financial avoided costs.

In the case of net billing, decisions are required about the level of the avoided cost rate. The rate could also vary by time of year or time-of-day and could also reflect non-financial values (e.g., GHG emission reductions).[9] This would provide a more complete signal regarding the value of on-site generation.

In the case of simple net metering, decisions are required about the length of time customers can bank net excess generation and the rate treatment of net excess generation at the end of the banking period. For example, many jurisdictions allow a customer to carry net excess generation forward for only one year. Any net excess generation at the end of a year is then granted to the utility free of charge. Alternatively, it can be settled at the avoided cost rate.[10]

4.2 Interconnection and other requirements

Interconnection issues may be dealt with as part of a net metering policy or as a separate stand-alone policy. Many utilities have developed their own interconnection standards and procedures to protect public safety and power quality, including liability and indemnification requirements for on-site generation. Advocates of small-scale generation sometimes criticize these standards and practices as being too onerous for small projects. It is very important to develop interconnection standards and procedures that achieve an acceptable balance between promoting small-scale generation with societal benefits and protecting safety / power quality.

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[9] A time-of-use rate provides a better indication of the value / cost of shaping energy services.

[10] The practice of granting next excess generation to the utility after one year is often justified as a means of preventing customers from installing systems that significantly exceeds their own annual energy requirements. The original intent of net metering was to provide customers with a way of enhancing the value of their generation rather than encouraging merchant plants.

4.3 Eligible technologies and system sizes

Many jurisdictions limit program participation to renewable electricity sources such as solar, wind and micro-hydro, since the societal benefits or these technologies are believed to outweigh some of the potential costs or impacts of net metering. A number of jurisdictions also permit co-generation technologies such as micro-turbines and fuel cells. Most jurisdictions place limits on the size of net metering installations in order to ensure systems meet the primary intent of offsetting customer consumptions and to minimize potential impacts on other customers. Most programs limit system size to 100 kW or smaller. However, a few jurisdictions do not put any limits at all on the type or size of technology.

4.4 Eligible customers

Many jurisdictions do not put any restrictions on eligible customers, although the restrictions on system type and size often creates practical limits on the types of customers that would likely participate. A few jurisdictions limit eligibility to residential, or residential and commercial customers.

4.5 Limits on overall enrollment

Some jurisdictions have placed limits on overall enrollment in order to minimize impacts on other customers, where these may be considered significant. Limits on enrollment are particularly common in programs that allow simple net metering to mitigate potential concerns about cross-subsidization by other ratepayers.

4.6 Linkages with other policies

Linkages to other policies and programs must also be considered in program design. For example, some jurisdictions with a renewable

portfolio standard allow utilities to count net metering installations towards their renewable energy goals. It is also important to avoid potential policy duplication. For example, net metering programs may need to be coordinated with Power Smart incentives to ensure ratepayers do not pay twice for energy savings.

5 Experience in Other Jurisdictions

5.1 Introduction

We conducted an informal survey of current programs and participation rates in Canada and the U.S.

Exact numbers of net metering customers are not available in most jurisdictions because utilities and government agencies are not required to keep accurate records of net metering or they consider this information proprietary. However, anecdotal information suggests that relatively few customers have actually participated in these programs to date. In California, where participation seems to be the highest, there are around 5,000 systems totaling approximately16.7 MW. In most other jurisdictions, however, the number of participants are measured in single or double figures.

Although proponents often point to a lack of promotion and other barriers to participation, there is considerable evidence that cost is a major factor deterring customers from installing on-site generation.

Program participation tends to be highest in jurisdictions with:

- simple net metering,
- high retail rates,
- widespread concerns about power reliability,[11] and
- additional rebates or other buy downs for small power systems.

[11] Some examples of events that contributed to customer awareness include the 1998 ice storm in New England and the California power crisis of 2000 and 2001. Ironically, on-site generation alone does not necessarily improve customer reliability. This depends upon the size and type of system and often requires additional control equipment, which increases upfront costs to customers.

The types of generation that are installed under net metering vary across jurisdictions, reflecting both eligibility guidelines and local economics. For example, solar is very prevalent in California, while wind is the predominant resource in Minnesota.

Most programs appear to have been implemented to enhance public perception and in response to programs being offered in other jurisdictions. Very few jurisdictions seem to have conducted an explicit cost benefit analysis of their net metering policies.

5.2 Experience in the United States

In the United States, there are currently 34 states that have state-mandated net metering programs (Figure 5-1). In some of these states, municipal or public utilities are excluded from formal state mandates but have nonetheless implemented their own programs. Finally, there are at least three states where net metering is not required but is offered voluntarily by one or more utilities. Congress has also been considering federal legislation that would mandate net metering nationally. Figure 5-2 through Figure 5-5 compare some key features of 46 different programs in the U.S.

Figure 5-1: Net Metering Programs in the United States

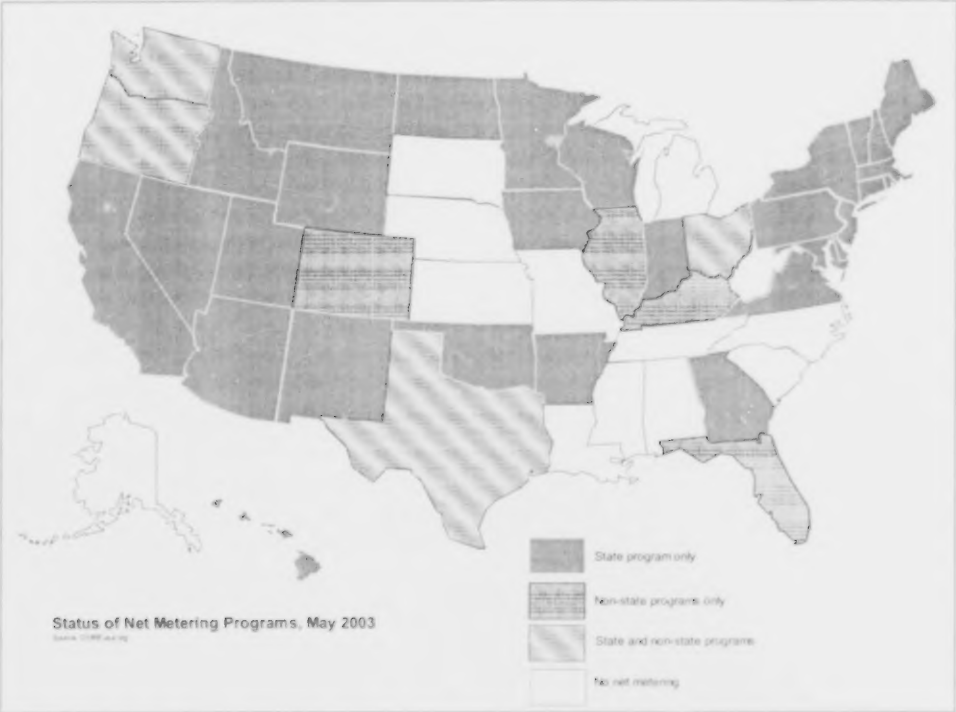

Status of Net Metering Programs, May 2003
State program only
Non-state programs only
State and non-state programs
No net metering

Figure 5-2: Eligibility of Different Technologies for Net Metering

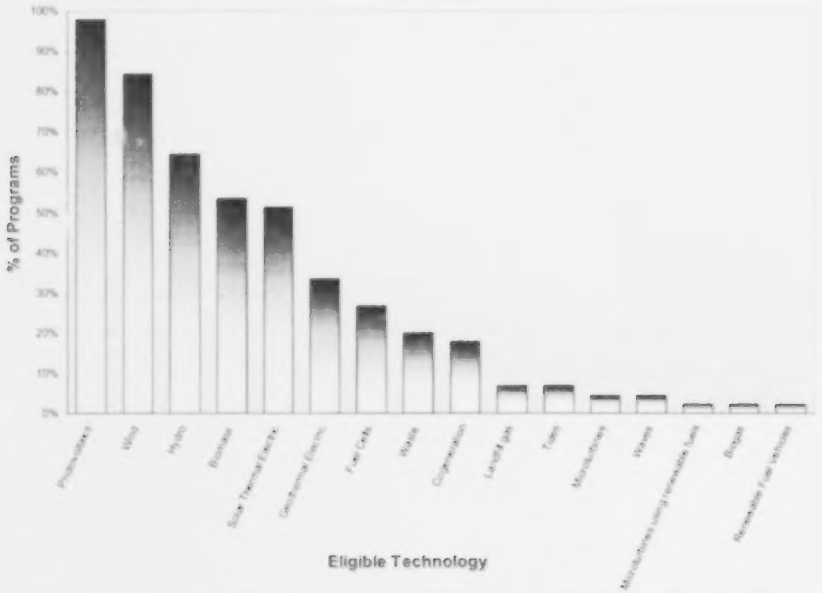


Figure 5-3: Cumulative Limits on Net Metering System Size

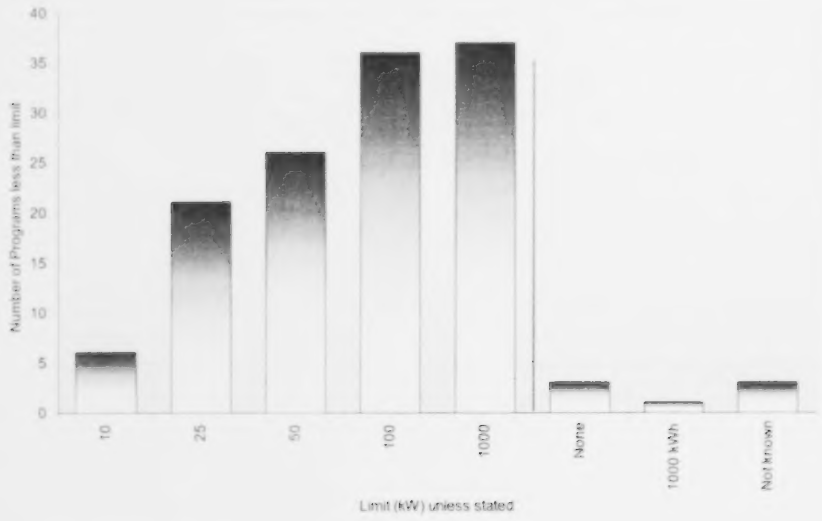


Figure 5-4: Treatment of Net Excess Generation

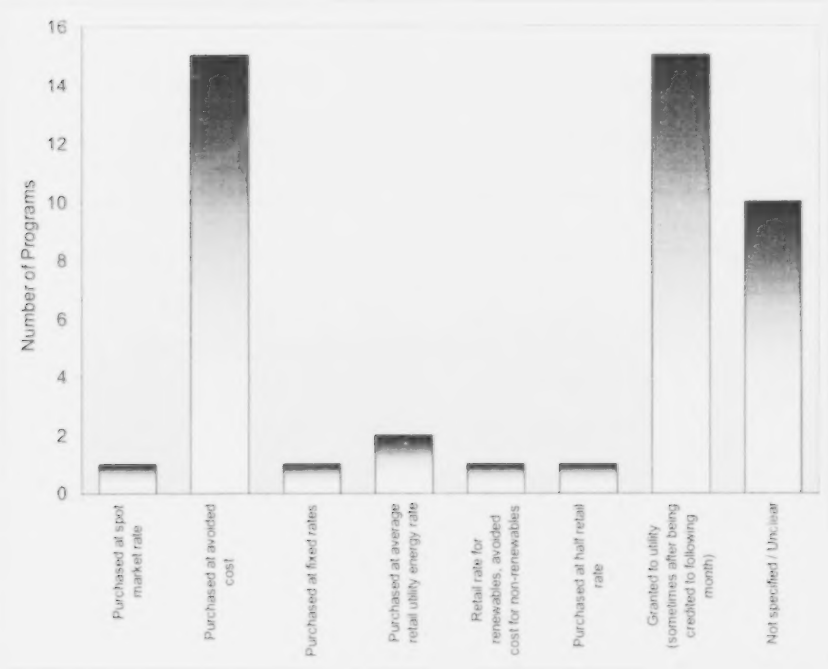
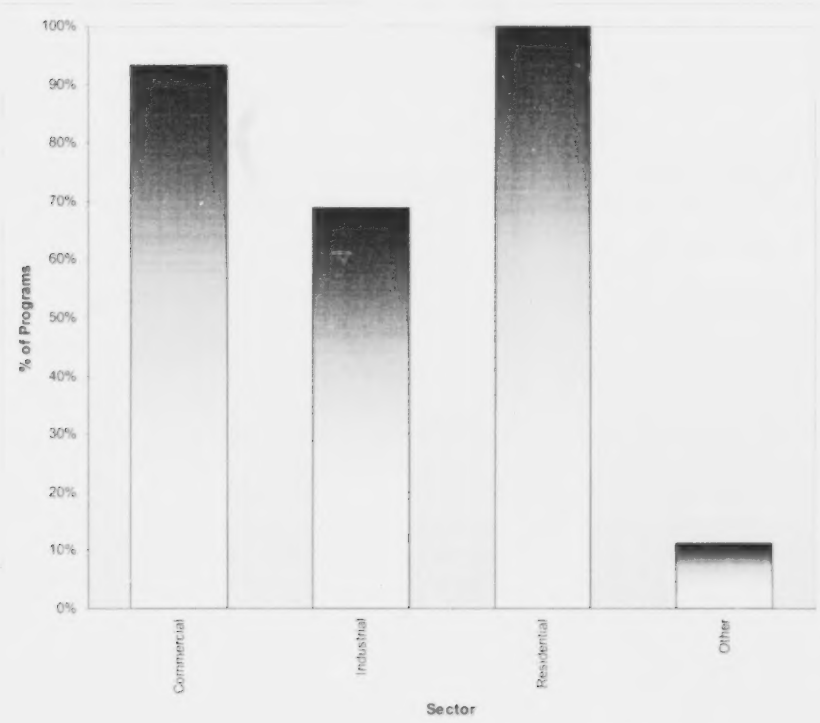


Figure 5-5: Eligible Customers



The following is some information on actual experience.

- The U.S. National Renewable Energy Laboratory recently conducted a survey of ten states with net metering.[12] The survey focused on wind energy uptake, but it also provided anecdotal information on general uptake for all eligible technologies. They

[12] Forsyth, T., M. Pedden, and T. Gagliano. 2002. *The effects of net metering on the use of small-scale wind systems in the United States*. National Renewable Energy Laboratory. Golden, Colorado.

found a total of 1,363 kW of installed small grid-connected wind at the end of 2001 in the ten states surveyed.[13]

- In California, net metering commenced in 1995 and was expanded in 2001 to systems up to 1 MW in size. The state also offers numerous financial incentives, has significant constraints on new supply, and is considered environmentally progressive. The NREL survey found that California has the largest number of documented net metering installations in the U.S. The California Energy Commission has paid rebates so far on 5,055 small-scale energy systems (primarily solar), with a total capacity of 16.7 MW. Most of these systems are net metered. This represents about 16 systems per 100,000 people and about 0.03% of peak demand in California.

Table 1: California Approved And Pending Net Metering Applications By Utility (December 2002)

	Number of Approved And Pending Customers	Capacity MW
Pacific Gas & Electric	2000	5.5 MW
San Diego Gas & Electric	500	4 MW
Edison	1500, 600 online	2.5 MW installed of 6 - 7 MW applied for.
Sacramento Municipal Utility District	1200	4 MW

Source: http://www.energy.ca.gov/distgen/notices/2002-11-18_forum/2002-11-18_MTG_MINUTES.PDF

[13] The states analyzed include California, Idaho, Illinois, Iowa, Maine, Minnesota, Nevada, Oregon, Vermont and Washington.

- Minnesota enacted a net metering law in 1983. There were 92 net metering projects in the State as of 2001. Nearly 70 projects are wind-based installations on farms, with the remainder made up of solar, micro-hydro, biomass, and other technologies. Interestingly, the number of wind projects has decreased from a high of 107 in 1997. This decrease is attributed to the several factors. First, some of the first systems were based on used equipment, which has now become too costly to operate. Second, many farmers and ranchers are installing larger turbines, which exceed the 40 kW capacity limit for net metering. Third, many farmers and ranchers have leased their land to developers of utility-scale wind systems in exchange for royalties.

- Oregon, which enacted a new law in 1999, has about 25 net metering systems. Current estimates are between 100 and 200 kW of installed capacity under net metering, still mostly in the form of solar PV.

- Washington, which enacted net metering in 1998, has approximately 51 net metering projects. The vast majority of these are solar PV systems attributed to the Whatcom Solar Rooftop Project. Of the Investor Owned Utilities in the state, Puget Sound Energy currently has 21 customers with a total capacity of 36.9 KW. Of these, 18 customers have solar PV and three customers have micro hydro. One of the solar customers also has a wind. PSE also has three more proposals pending which will increase capacity by about 59%. In Washington, Avista and PacifiCorp collectively have only a handful of net metering customers.

5.3 Canada

In Canada, net metering policies are in various stages of implementation or development in different jurisdictions.

- Aquila Networks offers a form of net billing in its service territory in B.C.

- Toronto Hydro established a net metering policy in 1997. The policy was suspended in 2001 following market deregulation. The program had fewer than 10 customers sign up, but it was also not well-publicized. Thirty customers also purchased solar PV systems

under a joint program with Greenpeace Solar Pioneers. However, these systems met only 10 to 15% of customer requirements and there was no flow of energy into the grid so net metering was not an issue.

- In Ontario, new legislation aimed at increasing local capacity will include a net metering program for generators up to 50kW.[14] Utilities are waiting for legislation before introducing net metering programs.

- Manitoba Hydro has had a program in place since 1989. As of 2000, there were only two net metering sites in the province – a 1 kW wind turbine and a small woodwaste plant located at a pulp mill. There does not appear to have been any additional installations since 2000.

- Nova Scotia Power established a net metering policy in the early 1990s. There are currently only two customers signed up. Despite a lack of promotion, the utility does receive many enquiries about net metering. However, there is very little follow-up once customers learn more about the capital costs of on-site generation. Nova Scotia Power is expecting a new government policy on net metering.

- In April 2002, the New Brunswick Market Design Committee recommended that distribution utilities allow net metering for renewable generators or co-generators less than 100 kW, with enrolment capped at 1% of the 5-year average maximum demand of the distribution utility. It also recommended that net metered customers have the choice of: 1) Monthly bill and payment cycle, with net injections over the month paid at the host utility's avoided cost; or 2) carryover of net injections which can offset net withdrawals in future months, with any net injections zeroed without compensation every 12 months. New Brunswick has not yet adopted any formal net metering policy and there is currently no activity pending passage of the new Electric Utilities Act

- Net metering is not legal in Alberta (i.e., running retail meters backwards). However, small generators can sell surplus electricity to the Power Pool. The province has developed standards for

[14] http://www.newswire.ca/releases/April2003/15/c1467.html

interconnecting small generation to the distribution system and the Alberta Energy and Utilities Board has also developed a simplified application process for small generation.

6 Policy Context in B.C.

British Columbia presently does not have a formal net metering policy.

The Province's new Energy plan - *Energy for our Future: A Plan for BC* (November 2002) - does not contain an explicit net metering policy. Policy Action # 20 states: "Electricity distributors will pursue a voluntary goal to acquire 50 percent of new supply from *BC Clean Electricity* over the next 10 years." The policy refers to net metering as an example of a possible tool to support this clean generation objective.

To date BC Hydro has focused on other strategies for meeting corporate objectives to develop green energy. Currently, it has two main initiatives underway.

- BC Hydro has issued three separate calls for power project proposals from IPPs. The 2000/01 Call resulted in power purchase agreements with 20 green power projects with a total output of 930 GW.h/year. Another 70 proposals totaling 5,500 GW.h were received in the 2002/03 call. Thirty of these projects with a total output of 3,300 GW.h/year were short-listed. Successful bidders will be announced in September 2003. The majority of these projects are hydroelectric plants, with some biomass and other alternate technologies.

- In 2002, BC Hydro launched its customer-based generation (CBG) program with a Request for Qualifications to supply up to 800 GW.h/year of new electricity from facilities located at customer sites.[15] Project submissions were evaluated against publicly disclosed mandatory requirements. Twenty-two projects were shortlisted and invited to submit final bids.

[15] This program is available to customers served under rate 1821, 1852, 1200, 1201, 1210 or 1211.

Seven submitted bids and five were ultimately successful. By September 2006, these projects will provide a total of approximately 500 GW.h per year of new electricity to BC Hydro's system.

BC Hydro plans to issue the next Call For Tenders for new supply sometime in 2004 in accordance with directions set out in the Energy Policy.

BC Hydro has experience connecting distributed generators. Since 1990, there have been more than 50 small-scale grid-connected generators in B.C. ranging from a 0.8 kW solar installation to a 14 MW hydro plant. Some of these facilities sell power to BC Hydro under contract. The rest do not currently export energy across their revenue meter.

BC Hydro has posted on its web site connection standards for small generators such as solar photovoltaics (to 5.5 kVA), along with interconnection standards for rotating machines (induction and synchronous generators).

7 Costs and Benefits of Net Metering

In this section, we review potential costs and benefits of net metering in B.C. As a starting point for discussions, we consider four key issues:

- Candidate technologies and technical potential for net metering.
- The relative societal costs of on-site generation and other sources of new supply.
- The potential costs or savings to participating customers and likely uptake.
- Possible impacts on non-participating customers.

7.1 Technical Potential

Most net metering policies limit eligible technologies based on local conditions and policy objectives. Technologies that may be feasible for net metering in B.C. include solar PV, wind, micro-hydro, small biomass, fuel cells and micro-turbines. Some jurisdictions also include fuel cells and microturbines. These can have environmental benefits if they are accompanied by co-generation.

There is a range of possible system sizes for each technology (Table 2). The appropriate size of these systems would depend upon the size of the customer load and quality of local resources (e.g., available wind or hydro resources).[16] For example, a typical single family household in B.C. consumes about 10,000 kW.h of electricity annually. A 0.5 kW solar PV array could produce 500 to 700 kW.h of electricity annually, depending upon local conditions. A 1 kW wind turbine could produce 1,300 to 3,000 kW.h per year depending upon local wind conditions. A 1 kW microhydro turbine, while a 3 kW version may produce 4,000 to 9,200 kW.h per year. A 1 kW micro-hydro system could produce 2,600 kWh to 6,000 kW.h per year. Larger systems would exceed the annual demand of residential customers, but may be suitable for commercial sites with larger loads, including agricultural customers. Appendix 1 provides a summary of the range of possible output from representative systems.

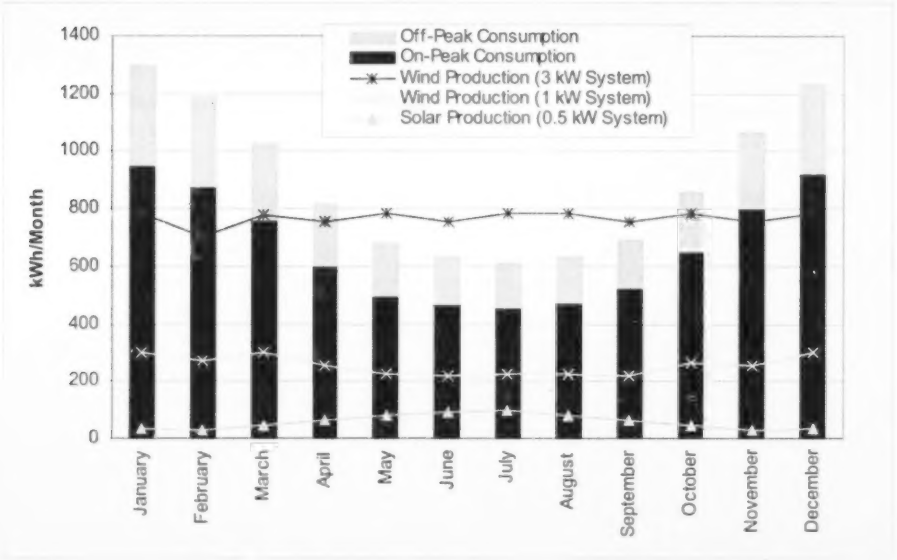
Figure 7-1 compares the monthly production from different systems with the consumption profile of a typical residential customer. As this figure illustrates, the energy produced by smaller systems (e.g., 0.5 kW or 1 kW wind turbine) would rarely, if ever, exceed the monthly peak or off-peak consumption of a residential customer. However, two-way flow of energy between the customer and grid may be possible across individual hours within the month. Production from larger wind, hydro or thermal systems could exceed customer consumption in certain months. Thus, the ability to bank energy in these months to offset excess higher consumption in other months may be beneficial (Figure 7-2).

[16] In the case of renewables such as solar, wind and micro-hydro, potential generation can vary greatly across sites, reflecting differences in available solar, wind and hydro energy. These differences are reflected as a range of potential capacity factors for each system.

Table 2: Examples of Technologies, System Sizes and Customer Classes

Technology	System Size(s)	Customer Type(s)
Solar PV	0.5 kW	Residential, commercial and agricultural
Wind	1, 3, 10 and 25 kW	Residential (1 and 3 kW only), commercial and agricultural
Micro-Hydro	1 to 10 kW	Residential (1 kW only), commercial and agricultural
Fuel Cell (with co-gen)	1 to 5 kW	Residential (1 kW only), commercial and agricultural
Microturbine (with co-gen)	1kW	Residential, commercial and agricultural

Figure 7-1: Sample Comparison of Residential Consumption Profile with Production Profiles for Different Generation Technologies*



*Based on a typical household consumption of 10,735 kW.h per year. The production profile for the 3 kW wind system is comparable to a 1.5 kW micro-hydro system (with 70% capacity factor) and a 1 kW fuel cell or microturbine. Production figures are not split into peak and off-peak periods. Although banking may not be required between months, some applications may still benefit from banking across hours within individual months.

Figure 7-2: Illustration of Net Monthly Consumption by a Residential Customer with a 3 kW Wind System*

*Based on consumption profile for a typical residential customer and 35% average capacity factor for wind system. In most months, monthly consumption would exceed production, although net metering could still facilitate some shaping within the month. In this example, net metering would also allow excess production between May and September to be used to offset net consumption in other months. Total annual consumption would still exceed total annual production.

In theory, fuel cells and microturbines could be installed anywhere gas supply is available. Fuel cells and microturbines can also be fuelled with alternative fuels such as biogas, which may be more limited to specific sites and quantities. The potential for solar, wind, micro-hydro and biomass is also limited by the size and quality of local resources. There are also often additional siting constraints for resources such as wind. For example, concerns about noise and aesthetic impacts typically limit wind installations to rural areas.

In 1999, an analysis conducted for the Solar Energy Society of Canada and the Association for the Advancement of Sustainable Energy Policy identified a *technical potential* for net metering of

between 308 and 879 GW.h per year, based on solar, wind and micro-hydro resources.[17] This represents roughly 0.5% to 1.5% of BC Hydro's current annual sales of electricity. In theory, the technical potential could be even higher if very small-scale residential wind was also included in this estimate.[18] This estimate probably represents the most optimistic assumption of resource potential based on the likely availability of suitable resources relative to customer sites. A more recent independent analysis of building integrated solar photovoltaic and small-scale wind estimated a technical potential for solar of 9 to 388 GW.h per year.[19] However, it estimates likely solar uptake in B.C. as about 10 GW.h, with another 25 GW.h from small-scale wind.[20]

7.2 Societal Costs and Benefits

As a proxy for the societal value of on-site generation, we compare its levelized unit cost of different small-scale generating technologies to BC Hydro's acquisition cost for new green generation.

A levelized cost simply reflects the unit cost of energy produced by a given system. Levelized costs are estimated by dividing annualized capital and operating costs by annual production from the system. We have computed a range of levelized costs for each technology, reflecting a range of assumptions about costs

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[17] Pape, Andrew. 1999. *Clean Power at Home*. Prepared for The Solar Energy Society of Canada Inc. (Ottawa) and the Association for the Advancement of Sustainable Energy Policy (Vancouver).

[18] We spoke with a local distributor that sells roof-top wind energy systems with capacities of 1kW and 3kW. However, the quality of wind resources tends to be reduced in urban areas, due to low turbine heights and interference from buildings. Concerns about noise and aesthetics are also heightened in urban areas.

[19] Smiley, Eric. 2002. *Green Energy Study for British Columbia: Mainland. Building Integrated Photovoltaic Solar and Small-scale Wind*. October 2002. British Columbia Institute of Technology.

[20] The study does not provide any specific justification for these assumptions.

and capacity factors in B.C. (Appendix 1).[21] The actual cost of most applications would fall somewhere within these ranges. To estimate societal benefits, we use a societal real discount rate (8%) and a long-run bulk gas price for thermal resources. This provides a more equal comparison with centralized resources.[22] Individual customers, however, would likely use higher discount rates and retail gas rates in deciding whether to actually install systems.

For the avoided cost for green energy, we use the range of possible prices in BC Hydro's recent Green Bid. This range assumes a base avoided cost of 5.5 cents / kW.h with adders and penalties for other system costs and benefits, including environmental benefits such as greenhouse gas reductions. For example, it includes an adder of up to $3/MW.h for greenhouse gas emission reductions, which is equivalent to approximately $10 / tonne. These adders and penalties produce a range of possible prices from 4.2 cents/kW.h to as high as 6.9 cents/kW.h. These adders may not capture all of the benefits (or costs) of small-scale generation, but they provide a useful basis for preliminary screening.

Figure 7-3 shows the range of premiums for each technology under the above assumptions. As this figure illustrates, there is a very wide range of potential premiums for small-scale generation. However, even under the most optimistic assumptions, many technologies are more costly on a levelized cost based than other sources of green energy supply. Some exceptions include wind and micro-hydro, which may be less costly under the most optimistic assumptions for installed costs, resource quality and avoided costs. The actual number of applications that might meet these optimistic assumptions is not known. In addition, the benefits of securing these resources through net metering must be weighed against the costs, other impacts of establishing a net

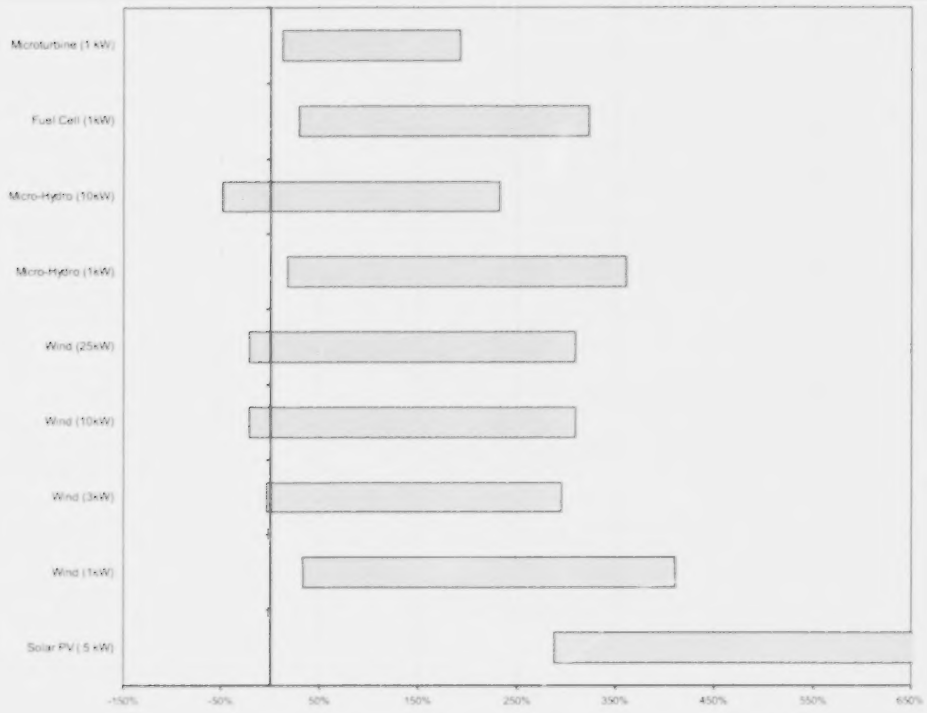
[21] Capital costs reflect equipment and installation costs. We have not included any specific costs for specialized interconnection equipment or additional meters in this analysis.

[22] Differences in the cost / value of shaping could be captured in a more thorough analysis through the use of time-of-use weighting factors for costs or revenues.

metering program, as well as the effectiveness of net metering in securing these resources.[23]

[23] There are other strategies that could be used to secure these resources – e.g., leasing and aggregating sites from land owners.

Figure 7-3: Premiums for Small-scale Generation in B.C. Relative to BC Hydro's Avoided Cost of New Supplies ($/kWh)*



*The premium is the difference between the levelized cost of on-site generation and BC Hydro's current avoided cost for green energy. The lower end of the range reflects the highest avoided cost for other sources of green energy and the most optimistic assumptions for technology costs and resource quality (i.e., best capacity factors). For example, the most optimistic levelized cost for a 1 kW wind turbine in B.C. is $0.09 / kWh. Subtracting BC Hydro's highest avoided cost for green generation of $0.07/kW.h leaves a premium of $0.02 / kW.h or 33% for a 1 kW wind turbine. The high-end premium for solar is greater than 700%.

7.3 Participating Customer Costs and Benefits

In the previous section we compared the societal levelized unit cost of on-site generation to BC Hydro's avoided costs for new green energy supply. In this section we use a customer's perspective on the costs of small-scale generation relative to retail rates. Specifically, we assume customers have a higher real discount rate (12%) and we use retail rates for the gas supply to fuel cells and microturbines.[24] This provides a useful indicator of the net benefits from a customer perspective assuming a simple net metering program (i.e., all production is valued at retail rates). If an alternative approach is used to value gross or net generation (e.g., avoided costs), the net benefits of a program from a customer perspective would could be higher (if avoided costs are higher than retail rates) or lower (if avoided costs are less than retail rates).

For simplicity, we compute levelized customer costs for the same range of technologies as above, changing only the discount rate and customer gas costs. We then compared these levelized customer costs to residential and commercial rates.[25] Representative installation costs for different systems are provided in Table 3.

[24] As with investments in energy efficiency, customer decisions are frequently based on a higher discount rate, reflecting a higher cost of capital, a higher individual time preference, and/or an additional premium for the risks associated with an alternative technology.

[25] In reality, some of these systems would be too large for a residential customer application.

Table 3: Installed Costs of Representative Systems

Technology	Installed Cost ($US / kW)*
Solar PV	3,000 – 10,000**
Wind	700 – 2,000
Microhydro	1,500 – 4,000
Fuel Cells	2,100 – 5,100
Microturbine	950 – 1,450

* Reflects range of equipment, installation and interconnection costs, which will vary across system sizes, configurations and sites. In addition to installed costs, many technologies also have other ongoing operating costs. Fuel cells and microturbines will also have fuel costs.

** Cost of building integrated PV could be partly offset by reductions in other material costs. This is reflected in the lower cost estimate.

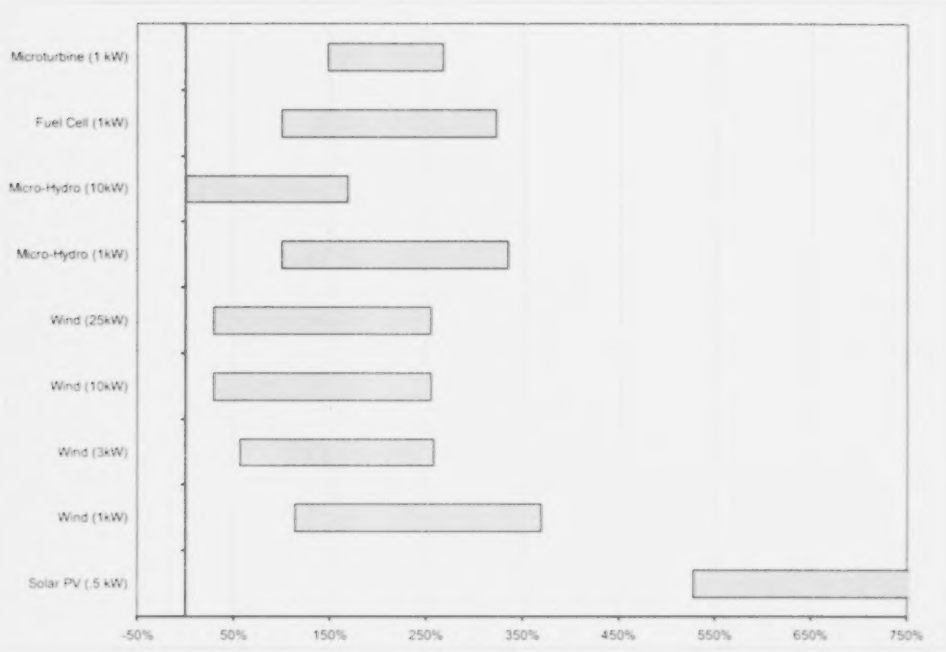
As above, there is a wide range of potential customer premiums associated with these technologies, reflecting possible ranges of installed costs and resource quality. However, all of the technologies are more costly from a customer perspective than current retail rates. For many technologies, the premium over retail rates exceeds 50%. A few technologies such as micro-hydro and larger wind applications may have a smaller but still positive premium. There would be little difference if gross or excess generation were valued at avoided costs since current retail rates are very similar to BC Hydro's avoided costs of green energy.[26]

Customers may be willing to pay some premium for other non-financial benefits, such as environmental benefits and satisfaction. However, based on the size of the premium significant uptake of net

[26] The difference between retail rates and avoided costs may change over time

metering would depend on highly motivated customers with very good resource potential on their sites.[27]

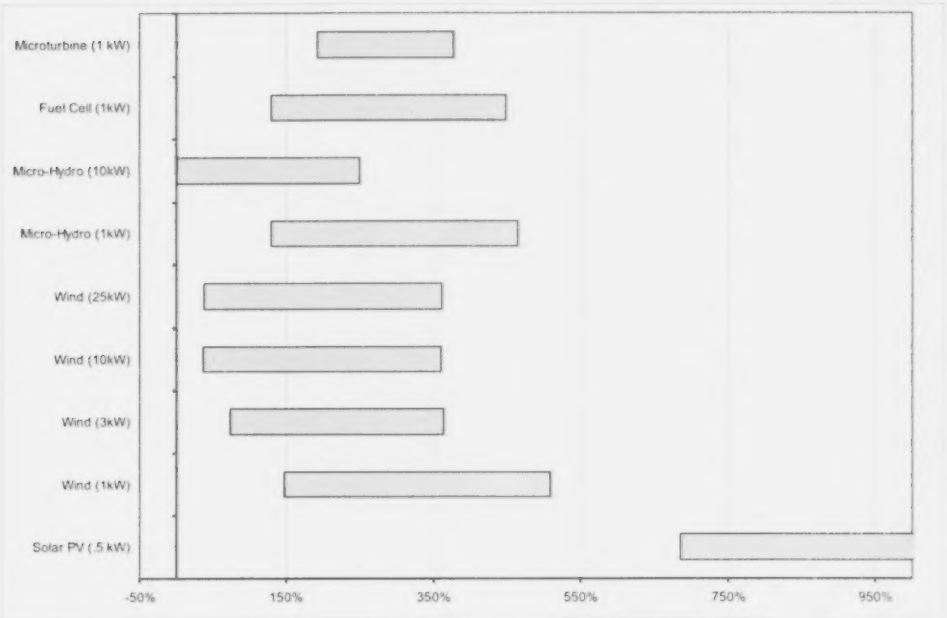
Figure 7-4: Representative Premiums for Small-scale Generation in B.C. Relative to Residential and Small Commercial Rates ($/kWh)*



* For simplicity, we use an average bundled retail rate of $0.065 / kW.h for residential and small commercial customers. The high-end premium for solar is greater than 900%.

[27] The best green pricing programs have achieved only 2 – 4% uptake with much lower premiums.

Figure 7-5: Representative Premiums for Small-scale Generation in B.C. Relative to Large Commercial Rate ($/kWh)*



* For simplicity, we use an average bundled retail rate of $0.046 / kW.h for large commercial customers. The high-end premium for solar is greater than 900%.

7.4 Possible Impacts on Non-Participating Customers

In this section we consider possible impacts on non-participating customers. In many jurisdictions, net metering can result in some cost shifting and/or ongoing cross subsidization if generation is valued at retail rates that do not reflect avoided costs. Depending upon their magnitude, such impacts may be acceptable as a result of other program benefits.[28] These impacts can also be partly managed through rate design (e.g., use of avoided cost rates) and/or limits on overall enrolment. In British Columbia, however, these impacts are somewhat limited by the fact that bundled retail rates are similar to current avoided costs of green generation (with green and other adders).

8 Hurdles

There are three main hurdles to net metering uptake.

The most obvious hurdle is **cost**. Although the optimum size of new plants has been declining in recent years, there are still modest economies of scale associated with most generating technologies including co-generation, wind, hydro, biomass, and geothermal technologies. For example, a 1.5 MW wind turbine can produce electricity at a much lower cost than a 100 kW turbine. Moreover, there are further economies of scale associated with installation of several dozen turbines in a single wind farm. As a result, small-scale technologies still have a higher levelized cost than larger ones.[29]

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[28] Existing rate structures contain numerous cross-subsidies – e.g., postage stamp rates and flat rates.

[29] Control system costs do not always decrease proportionally and can sometimes override this effect.

Even where these technologies are competitive on a lifecycle basis with other forms of green or conventional generation, upfront capital costs can be a barrier for many customers.

There are several possible strategies for addressing these cost hurdles. These include the following.

- Utility programs can be designed to minimize costs wherever possible – e.g., minimize metering and interconnection costs as much as possible subject to meeting minimum safety and power quality needs.[30]

- Financing (by utilities or a government agency) can help to overcome capital cost barriers. However, financing strategies cannot significantly alter the levelized lifecycle cost of these technologies.

- Government or utility rebates are available in some jurisdictions to offset the upfront cost of some technologies (e.g., rebates for solar PV in California). This can have a significant impact on economics. However, the subsidy must be evaluated against public benefits (e.g., GHG reductions) and alternative means of acquiring those benefits (e.g., subsidies to utility-scale projects). These will vary greatly across jurisdictions.

- Production subsidies (e.g., tax rebates) can also be used to reduce the levelized cost to customers. However, these

[30] Universal interconnection standards across jurisdictions could help to reduce the cost of systems by facilitating common solutions to safety and power quality problems by manufacturers and installers, eliminating the need for additional design and equipment expenses that may vary across jurisdictions or sites. In the U.S., 15 states have developed common interconnection standards for utilities within their jurisdiction (As of May 2003, these are Arkansas, Delaware, D.C., Maryland, Montana, New Hampshire, New Jersey, New Mexico, New York, Oregon, Utah, Vermont, Virginia, Washing ton and Wyoming). In 2000, the Institute of Electrical and Electronics Engineers (IEEE) Standards Board approved a standard (929-2000) for interconnecting photovoltaic (PV) systems under 10 kW to the utility grid. In September, 2002, the IEEE also voted 90% in favour of the IEEE P1547 Draft Standard for Interconnecting Distributed Resources with Electric Power Systems. In Canada, MicroPower Connect –a collaborative effort, the EEMAC Council within Electro-Federation Canada, Natural Resources Canada and Industry Canada established 2 years ago– is trying to develop a Canadian guideline for the interconnection of small inverter-based power sources (PV, fuel cells, wind, microturbines).-

tend to be les effective than capital cost reductions, particularly given the sensitivity of small customers to upfront costs.

These strategies could be implemented in different combinations by governments and/or utilities.

A second barrier is **institutional**. Net metering advocates frequently identify utility Interconnection standards as an example of an important institutional barrier to net metering. However, institutional barriers also extend beyond the utility. For example, building inspectors and local permitting authorities could hinder or increase costs and effort involved in installing on-site generation. The availability and cost of insurance can also be an important barrier to potential customers.

A final barrier is **awareness**. Even if cost and institutional barriers are eliminated, lack of awareness can greatly limit uptake.

There is a logical order to addressing these barriers. Institutional changes and increased awareness will do little to promote uptake in the face of very high costs for customers.

9 Summary

- Net metering is a tool to facilitate the sale or banking of excess energy produced by small-scale, grid-connected energy generation located in homes or businesses.

- Net metering is not required for a customer to install on-site generation. However, it can improve the economics of systems where production will exceed consumption for certain time periods.

- Net metering programs in jurisdictions outside B.C. vary greatly in terms of their approach to metering and billing, their treatment of net excess generation, eligible technologies, eligible customers and enrolment limits. These differences reflect different objectives and trade-offs in each jurisdiction.

- Many jurisdictions have implemented net metering to manage public perception and in response to trends elsewhere. Most

programs have not been subjected to a formal cost benefit analysis.

- There has been very limited uptake of net metering in most jurisdictions. Uptake is greatest in jurisdictions where all generation is valued at retail rates, retail rates are high, there is a heightened customer concern about reliability, and there are significant rebates or buy-downs for small-scale energy systems. Not all programs have been well-marketed.

- Based on most applicable technologies and excluding thermal resources such as fuel cells and microturbines, the technical potential for net metering in B.C. is 0.5 to 1.5% of total provincial electricity consumption.

- The costs of many forms of small-scale generation exceed BC Hydro's current avoided cost for new green energy, including some adders for benefits such as GHG emission reductions. Some exceptions include micro-hydro and larger-scale wind energy systems at very good sites. The proportion of total net metering potential available at these lower costs is unknown. There may also be other societal benefits that could justify some premium. Realizing these benefits would also require voluntary customer uptake.

- Under the most favourable assumptions of installation costs, resource quality and rate treatment, customer costs in the absence of additional subsidies would exceed current retail rates in virtually all circumstances. Customers have expressed a willingness to pay a premium for other indirect and societal such as environmental improvements. However, uptake would depend upon customer ability and willingness to pay a substantial premium (in many cases exceeding 50%) for these other benefits. These economics may change with future changes in technology costs and retail rates.

- The magnitude of potential cost-shifting and/or cross-subsidization as a result of net metering is limited in B.C. by the fact that current bundled retail rates are very close to BC Hydro's current avoided costs of green energy. This situation may change over time with changes in retail rates and changes in avoided costs.

- Interconnection standards for small generation are an important issue that may be dealt with as part of a net metering policy or as a separate policy.

- The costs and benefits of net metering should be examined in comparison with other options and priorities for promoting economic and environmental objectives in B.C.

Appendix – Detailed Assumptions

Table 4: Assumptions for Calculation of Levelized Societal Costs

Operating costs for fuel cells and microturbines are based on a long-run levelized cost of gas of 3.3 US$/GJ and include a heat credit based on expected heat recovery and operating cost of a boiler at 85% efficiency. Annualized capital costs reflect an 8% real discount rate. Capital costs are based on equipment and installation costs obtained from EPRI, manufacturers and other sources. US$ prices are converted using a long-term exchange rate of 0.75 C$/US$. Ranges for capacity factors reflect likely ranges for sites in B.C.

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
System Size (kW)	0.5	1	3	10	25	1	10	1	1
System Life	30	30	30	30	30	30	30	30	15
Amortization	30	30	30	30	30	30	30	30	15
Annual Capacity Factor									
High	16%	35%	35%	35%	35%	70%	70%	95%	95%
Base	14%	25%	25%	25%	25%	55%	55%	90%	90%
Low	12%	15%	15%	15%	15%	30%	30%	80%	80%
Installed System Costs (US$/kW)				975					
High	10,000	2,000	1,500	1,500	1,500	4,000	2,500	5,100	1,450
Base	5,500	1,800	1,200	1,000	1,000	3,750	2,000	2,600	1,250

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
Low	3,000	1,600	1,000	700	700	3,500	1,500	2,100	950
Fixed Costs (US$/kW-yr)									
High	15.4	15.0	15.0	15.0	50.0	0.0	0.0	10.0	10.0
Base	15.4	15.0	15.0	15.0	50.0	0.0	0.0	10.0	10.0
Low	15.4	15.0	15.0	15.0	50.0	0.0	0.0	10.0	10.0
Operating Costs - Net of Heat Credit for Co-Gen (US$/kWh)									
High	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.07	0.06
Base	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.05	0.05
Low	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.04	0.04
Electrical Efficiency (w/ co-gen)									
High Cost Case								30%	20%
Base Cost Case								40%	25%
Low Cost Case								50%	30%

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
Heat Recovery									
High Cost Case								30%	40%
Base Cost Case								35%	45%
Low Cost Case								35%	50%
Total Annual Production (kWh)									
High	701	3,066	9,198	30,660	76,650	6,132	61,320	8,322	8,322
Base	613	2,190	6,570	21,900	54,750	4,818	48,180	7,884	7,884
Low	526	1,314	3,942	13,140	32,850	2,628	26,280	7,008	7,008
Annualized Capital Costs (C$/year)									
High	592	237	533	1,777	4,441	474	2,961	604	226
Base	326	213	426	1,184	2,961	444	2,369	308	195
Low	178	189	355	829	2,073	415	1,777	249	148
Total Annual Costs (C$/year)									
High (High Costs and Low Capacity Factor)	602	282	648	2,137	5,351	509	3,136	1,224	816

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
Base (Base Costs and Capacity Factor)	336	282	612	1,778	4,454	508	2,690	879	724
Low (Low Costs and High Capacity Factor)	188	281	611	1,657	4,150	496	2,185	741	612
Levelized Unit Cost (C$ / kWh)									
High (High Costs and Low Capacity Factor)	1.15	0.21	0.16	0.16	0.16	0.19	0.12	0.17	0.12
Base (Base Costs and Capacity Factor)	0.55	0.13	0.09	0.08	0.08	0.11	0.06	0.11	0.09
Low (Low Costs and High Capacity Factor)	0.27	0.09	0.07	0.05	0.05	0.08	0.04	0.09	0.07
Difference between High and Low	0.88	0.12	0.10	0.11	0.11	0.11	0.08	0.09	0.04
Avoided Cost									
Low	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
High	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069	0.069
Premium Relative to Avoided Costs									
High	2629%	411%	291%	287%	288%	361%	184%	316%	177%

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
Low	289%	33%	-4%	-22%	-22%	17%	-48%	29%	7%
Difference	2340%	378%	295%	309%	309%	344%	232%	287%	171%

Table 5: Assumptions for Calculation of Levelized Customer Costs

Based on similar assumptions as above but using a discount rate of 12% and a long-run levelized gas rate of 8 US$/GJ.

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
System Size (kW)	0.5	1	3	10	25	1	10	1	1
System Life	30	30	30	30	30	30	30	30	15
Amortization	30	30	30	30	30	30	30	30	15
Annual Capacity Factor									
High	16%	35%	35%	35%	35%	70%	70%	95%	95%
Base	14%	25%	25%	25%	25%	55%	55%	90%	90%
Low	12%	15%	15%	15%	15%	30%	30%	80%	80%
Installed System Costs (US$/kW)				975					
High	10,000	2,000	1,500	1,500	1,500	4,000	2,500	5,100	1,450
Base	5,500	1,800	1,200	1,000	1,000	3,750	2,000	2,600	1,250

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
Low	3,000	1,600	1,000	700	700	3,500	1,500	2,100	950
Fixed Costs (US$/kW-yr)									
High	15.4	15.0	15.0	15.0	50.0	0.0	0.0	10.0	10.0
Base	15.4	15.0	15.0	15.0	50.0	0.0	0.0	10.0	10.0
Low	15.4	15.0	15.0	15.0	50.0	0.0	0.0	10.0	10.0
Operating Costs - Net of Heat Credit for Co-Gen (US$/kWh)									
High	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.10	0.14
Base	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.07	0.11
Low	0.00	0.02	0.02	0.02	0.02	0.01	0.01	0.05	0.09
Electrical Efficiency (w/ co-gen)									
High Cost Case								30%	20%
Base Cost Case								40%	25%
Low Cost Case								50%	30%

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
Heat Recovery									
High Cost Case								30%	40%
Base Cost Case								35%	45%
Low Cost Case								35%	50%
Total Annual Production (kWh)									
High	701	3,066	9,198	30,660	76,650	6,132	61,320	8,322	8,322
Base	613	2,190	6,570	21,900	54,750	4,818	48,180	7,884	7,884
Low	526	1,314	3,942	13,140	32,850	2,628	26,280	7,008	7,008
Annualized Capital Costs (C$/year)									
High	828	331	745	2,483	6,207	662	4,138	844	284
Base	455	298	596	1,655	4,138	621	3,310	430	245
Low	248	265	497	1,159	2,897	579	2,483	348	186
Total Annual Costs (C$/year)									

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
High (High Costs and Low Capacity Factor)	838	376	860	2,843	7,117	697	4,313	1,805	1,571
Base (Base Costs and Capacity Factor)	465	366	781	2,249	5,631	685	3,632	1,207	1,370
Low (Low Costs and High Capacity Factor)	259	357	752	1,986	4,974	661	2,892	900	1,143
Levelized Unit Cost (C$ / kWh)									
High (High Costs and Low Capacity Factor)	1.59	0.29	0.22	0.22	0.22	0.27	0.16	0.26	0.22
Base (Base Costs and Capacity Factor)	0.76	0.17	0.12	0.10	0.10	0.14	0.08	0.15	0.17
Low (Low Costs and High Capacity Factor)	0.37	0.12	0.08	0.06	0.06	0.11	0.05	0.11	0.14
Difference between High and Low	1.23	0.17	0.14	0.15	0.15	0.16	0.12	0.15	0.09
Retail Rates									
Residential	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Commercial	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.05

	Solar PV 500 W	Wind 1kW	Wind 3kW	Wind 10 kW	Wind 25 kW	Micro-Hydro 1 kW	Micro-Hydro 10 kW	Fuel Cell Co-gen 1kW	Microturbine Co-gen 1kW
Premium Relative to Residential Rates									
High	2513%	369%	258%	255%	255%	335%	169%	322%	268%
Low	528%	114%	57%	29%	29%	100%	0%	100%	148%
Difference	1986%	256%	201%	226%	226%	235%	169%	222%	119%
Premium Relative to Commercial Rates									
High	3292%	509%	364%	360%	361%	464%	249%	448%	377%
Low	685%	147%	74%	38%	38%	129%	0%	130%	192%
Difference	2607%	362%	290%	323%	323%	335%	249%	318%	185%